WHAT IS CLAIMED IS:

1. Apparatus comprising:

a first end-cap electrode, a second end-cap electrode, and a ring electrode positioned relative to the first end-cap electrode and second end-cap electrode to confine a charged particle from an ion source within a confinement region when an audio frequency voltage is applied between the ring electrode and the first end-cap electrode and second end-cap electrode at a first amplitude, and to eject the charged particle from the ion trap when the amplitude of the audio frequency voltage is increased to a second amplitude.

2. The apparatus of claim 1 wherein the first end-cap electrode includes an ion entrance aperture, the second end-cap electrode includes an ion ejection aperture, and the ring electrode includes an observation aperture.

3. The apparatus claim 1, further comprising a light detection module that detects light scattered from the charged particle after it is ejected from the ion trap.

4. The apparatus of claim 1 wherein the ion source is positioned above the ion trap and includes a needle, a capillary, and a differential pumping region, the needle being aligned along a vertical axis above the capillary, the capillary being aligned along the vertical axis above the differential pumping region.

5. The apparatus of claim 4 wherein the capillary and the differential pumping region are electrically connected to electric ground and the needle is connected to a DC voltage.

6. The apparatus of claim 1 wherein the audio frequency voltage is in a frequency range between about 50 and 2000 hertz.

7. The apparatus of claim 1 wherein the charged particle has a mass in the range of about 1 mega-dalton to 10,000 mega-daltons.

8. The apparatus of claim 1 wherein the first amplitude is about 400 volts.

9. The apparatus of claim 8 wherein the second amplitude is greater than about 400 volts and less than about 1700 volts.

10. A method comprising:

introducing a charged particle into an ion trap having a first end-cap electrode, a second end-cap electrode, and a ring electrode positioned between the first and second end-cap electrodes;

applying an audio frequency voltage having a first amplitude between the ring electrode and the end-cap electrodes to generate an electromagnetic field that confines the charged particle within a confinement region; and

increasing the amplitude of the audio frequency voltage to a second amplitude to eject the charged particle from the ion trap.

11. The method of claim 10, further comprising measuring a secular frequency of the motion of the charged particle inside the confinement region, and calculating a mass-to-charge ratio of the charged particle based on the second amplitude and the measured secular frequency.

12. The method of claim 10 wherein the audio frequency voltage is in a frequency range between about 50 and 2,000 hertz.

13. The method of claim 10 wherein the charged particle has a mass in the range of about 1 mega-dalton to 10,000 mega-daltons.

14. The method of claim 10, further comprising illuminating the ejected particle with a laser beam and detecting light scattered from the charged particle.

15. A mass spectrometer comprising:

an ion source;

an ion trap having:

a first end-cap electrode, a second end-cap electrode, and a ring electrode positioned relative to the first and second end-cap electrodes to confine a charged particle from the ion source within a confinement region when an audio frequency voltage is applied between the ring electrode and the first and second end-cap electrodes at a first amplitude, and to eject the charged particle from the ion trap when the audio frequency voltage is applied between the ring electrode and the first and second electrodes at a second amplitude greater than the first amplitude; and

a detection module configured to detect the charged particle after it is ejected from the ion trap.

16. The mass spectrometer of claim 15, further comprising an audio frequency power amplifier that generates the audio frequency voltage.

17. The mass spectrometer of claim 15 wherein the audio frequency voltage is in a frequency range between about 50 and 2,000 hertz.

18. The mass spectrometer of claim 15 wherein the first end-cap electrode includes an ion entrance aperture, the second end-cap electrode includes an ion ejection aperture, and the ring electrode includes an observation aperture.

19. The mass spectrometer of claim 15, wherein the detection module comprises a light source to illuminate the charged particle after it is ejected from the ion trap.

20. The mass spectrometer of claim 19 wherein the detection module further comprises a light detector that detects light scattered by the charged particle that is ejected from the ion trap.

21. The mass spectrometer of claim 15 wherein the ion source is positioned above the ion trap and includes a needle, a capillary, and a differential pumping region, the needle being aligned along a vertical axis above the capillary, the capillary being aligned along the vertical axis above the differential pumping region, the capillary and the differential pumping region being electrically connected to electric ground, and the needle being connected to a DC voltage.

22. The mass spectrometer of claim 15 wherein the charged particle has a mass in the range of about 1 mega-dalton to 10,000 mega-daltons.

23. The mass spectrometer of claim 15 wherein a mass-to-charge ratio (m/z) of the charged particle is calculated using $m/z = \frac{4\,V_{eject}}{q_{eject}\,r^2\,\Omega^2}$, where V_{eject} is the value of the second amplitude, r is the radius of the ring electrode, Ω equals 2π times the frequency of the audio frequency voltage, and q_{eject} is a calibration parameter characteristic of the ion trap.

24. The apparatus of claim 23 wherein the mass-to-charge ratio calculated using the equation $m/z = \frac{4\,V_{eject}}{q_{eject}\, r^2\, \Omega^2}$ has an accuracy in the order of 10^{-4}.

25. An ion source for use with a mass spectrometer, comprising:

a needle having a first dimension and being electrically connected to a DC voltage;

a capillary having a second dimension and being electrically connected to electric ground and aligned along a vertical axis below the needle; and

a differential pumping region including a first region having a first pressure and a second region having a second pressure, the differential pumping region being electrically connected to electric ground and aligned along the vertical axis below the capillary;

wherein the first and second dimensions and the first and second pressures are selected such that particles generated by electrospray ionization become fully dispersed into separate single particles after sequentially passing through the needle, the capillary, and the first and second regions of the differential pumping region.

26. A method of detecting a charged particle ejected from an ion trap of a mass spectrometer, comprising:

illuminating the charged particle using a light source; and

detecting light scattered from the charged particle using a light detector.

27. A method comprising:

introducing a charged particle into an ion trap of a mass spectrometer, the ion trap having a first end-cap electrode, a second end-cap electrode, and a ring electrode positioned between the first and second end-cap electrodes;

applying an AC voltage having a frequency of f and an amplitude of V_{ac} between the ring electrode and the end-cap electrodes to generate an electromagnetic field that confines the charged particle within a confinement region;

measuring a secular frequency ω representing the oscillation frequency of the motion of the charged particle within the confinement region;

increasing the amplitude of the AC voltage to a second amplitude V_{eject} to eject the charged particle from the ion trap; and

calculating a calibration parameter q_{eject} based on V_{ac}, V_{eject}, f, and ω, the calibration parameter being used to calculate a mass-to-charge ratio of another charged particle that is introduced into the ion trap and ejected from the ion trap.

28. The method of claim 27 wherein the calibration parameter q_{eject} is calculated using the equation $q_{eject} = \frac{V_{eject}}{V_{ac}} \frac{4\sqrt{2}\omega}{\Omega}$, where $\Omega = 2\pi f$.

29. The method of claim 28, further comprising measuring the radius r of the ring electrode, and calculating the mass-to-charge (m/z) ratio of the other charged particle using the equation $m/z = \frac{4\,V_{eject2}}{q_{eject}\,r^2\,\Omega^2}$, where V_{eject2} is the amplitude of the AC voltage when the other charged particle is ejected from the ion trap.